TABLE 20.—*Data relative to the principal rivers of Porto Rico.*

Name.	Approximate length.	Approximate area of catchment basin.	Approximate average minimum discharge, per second.	Principal tributaries.	Cooperative stations situated in basin.
North side.	*Miles.*	*Sq. miles.*	*Cubic feet.*		
Sabana	6.2				Perla.
Rio Grande	9.3				None.
Loiza	36.7	376	1,600		Canóvanas. Caguas. San Lorenzo.
Bayamon	29.4	114			Bayamon.
Rio de La Plata	44.0	256	230		Cidra. Cayey. Comerio. Aibonito.
Cibuco	15.6				Morovis. Corozal.
Manati	30.1	283			Manati. Barros.
Arecibo	28.2	343	100	Tanamá	Arecibo. Utuado. La Isolina. San Salvador. Adjuntas.
Camuy	19.3				None.
Guajataca	18.4				None.
East side.					
Fajardo	10.7	35			Fajardo.
Rio Blanco	10.0	34			None.
Humacao	9.8				Humacao.
Guayanes	13.6	44			None.
South side					
Patillas	8.7				None.
Guamani	8.7				Guayama.
Rio de la Lapa	10.1	71			Salinas.
Coamo	17.7	97	100		Coamo.
Jacaguas	13.2	80	50	Garcia	Juana Diaz.
Portugués	13.7		25		Ponce.
Canas	12.2		35		None.
Tallaboa	11.1	38			None.
Duey (Yauco)	16.7	67			Yauco.
West side.					
Culebrinas	21.1	107	100		Coloso.
Añasco	35.1	194	1,000	Prieto.	Las Marias.
Yagüez (or Mayagüez)	9.1				Mayagüez.
Guanajibos	24.0	135		Rosario. Viejo. Hoconuco.	San German.

A NEW FORM OF PRECISION BAROGRAPH.

By C. F. MARVIN, Professor of Meteorology, U. S. Weather Bureau. Dated June 20, 1906.

Modern instrumental meteorology owes a distinct debt of obligation to Monsieur Jules Richard and his predecessors, the firm of Richard Freres, for their inventions of many forms of recording meteorological instruments. More than twenty years ago they put on the market simple and reliable forms of barographs and thermographs, at a time when simple and practical instruments of this kind for ordinary observatory use were scarcely known. These are now extensively used everywhere, and, in the meantime, have been followed by many other ingenious instruments.

Their latest accomplishment is a new type of the aneroid barograph in which the pressure of the air is balanced against a massive weight. The following translation of their own description of the instrument, which is shown imperfectly in fig. 1, fully explains its construction.

BAROMÈTRE A POIDS.

The weighted aneroid barometer.

This recording barometer of precision and great sensitiveness is based upon the aneroid principle, that is to say, upon exhausted chambers compensated for temperature. The chambers, or cells, are separately exhausted and do not contain any spring within. They are screwed together, one above the other, and the one on top is provided with a massive ring fixed to a metallic frame which is secured to the case at its extremities, and at the same time sustains the recording system in such a manner that any yielding due to the pull of the weight can have no effect on the barometric trace.

The mass required to counterpoise the air pressure on one of the barometric chambers weighs 126 kilograms, and as the cells are joined together "in tandem" the same weight suffices to counterpoise all.

In the ordinary aneroid barometer the only element lacking stability is the spring. All the errors come from this source, for, with time and changes of temperature, its elasticity undergoes modification; it weakens little by little, and the barometer tends to rise, especially in the first days of its construction. By replacing the spring by a weight, one obtains an instrument which conserves its zero point and becomes a veritable standard, easy to transport, which is not true for the mercurial barometer. To transport the weighted aneroid it is necessary only to unhook the weight, which can be replaced at destination without any difficulty.

Another advantage in the weighted aneroid is that it registers equally seismic shocks, as well as the slow variations of the intensity of gravity accompanying the phenomena of tides. By comparing the curves of a weighted aneroid with those of a spring aneroid at the same place and regulated in the same manner, one may find in the differences some indications of the variations in the intensity of gravity.

Seismic shocks are generally so instantaneous and so feeble that they pass unperceived. The weighted aneroid records the precise hour at which they occur and, in part, their intensity, without the need of special apparatus for this purpose, such as seismographs, which are so rarely called upon to perform their function in our locality that they are almost always not in operation.

The weighted aneroid is made in two models. The one represented in the cut herewith gives a deviation on the paper of 3 millimeters per millimeter of the mercurial barometer, and is provided with a cylinder of 125 millimeters diameter making one revolution per week. The second model is much more sensitive, that is, 10 millimeters it may be, or 20 millimeters, per millimeter of mercury, and has a cylinder 303 millimeters in diameter making one rotation per day. In an instrument of great sensibility it frequently happens that the pen passes beyond the margins of the record sheet, whereupon it becomes necessary to return the pen to the middle of the sheet in order to avoid interruption of the record. Generally this may be accomplished by hand, by operating a button for this purpose, but a model is made where this operation is effected automatically by the aid of an electric motor.

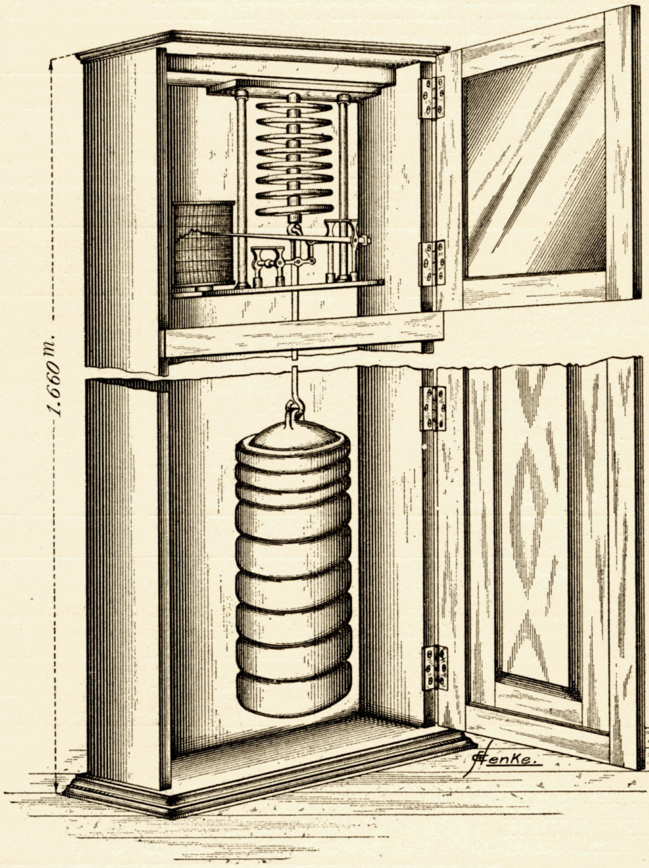

FIG. 1.—Weighted aneroid barograph. (Richard.)

The instrument thus described embodies a distinctly new departure in aneroid construction, and probably attains increased accuracy and constancy in barographs of this form. The writer is hardly prepared to admit, however, that variations in gravity can be satisfactorily shown by this instrument, or that "the only element lacking stability in aneroid barometers of the ordinary construction is the spring".

In discussing the irregular movements exhibited by aneroids the following statements were made by the writer in a previous publication:[1]

It seemed to me that the real seat of the greater part, if not all of the

[1] Monthly Weather Review, September, 1898. Vol. XXVI, p. 410.

after effect, or creeping, is in the corrugated aneroid vacuum boxes themselves, as distinguished from the tempered steel springs that are employed to keep the box from collapsing under the pressure of the air. This conviction was forced upon my mind after reading Mr. Whymper's valuable paper on the errors of the aneroid, and in 1892 I made the following simple experiment, which greatly confirmed this supposition: The vacuum box of an old aneroid was removed, and a heavy weight (a trifle over fifty pounds was required) was applied directly to the steel spring, thereby straining it as nearly as possible to the same extent as did the air pressure exerted through the medium of the corrugated vacuum box. Any desired changes in the position of the index were made by appropriate changes in the weight. No after effect comparable in magnitude with that exhibited by ordinary aneroids was ever observed. In other words, this tempered steel spring behaved to all intents and purposes as if it were a *perfectly* elastic body. Readings of the pressure scale could be made corresponding to about 0.005 of an inch on the barometer. A careful or full investigation was not attempted. I believe, nevertheless, that the tempered steel springs employed in all aneroids are, or may easily be made to be, highly trustworthy. On the other hand, the process of constructing the vacuum boxes is well calculated to develop therein irregular and imperfect elastic properties in the highest degree. The top and bottom surfaces are each formed of a thin circular sheet of metal, with a narrow rim bent up around the edge. In order to give flexibility, several concentric corrugations are formed over quite the whole face of the disk. The crimping and bending operations necessary in the manufacture of these corrugated disks have a marked effect upon the elastic qualities of the metal, which, to make matters worse, is generally of brass, german silver, or some similar alloy well known to be only imperfectly elastic under the most favorable conditions. The metal must originally be, more or less, in a soft and annealed condition in order to withstand the corrugating and bending operations. Those portions which are stretched and compressed by the process become stiffer and more elastic, and a most complex and irregular system of internal stresses and strains exists within the finished disk. The arrangement of molecules is undoubtedly a highly unstable one, and it is not surprising that large, discontinuous, and unexpected changes take place in the readings of the finished instrument.

A careful examination of the theory of the weighted aneroid will show that the massive weight does not counterpoise all the air pressure upon the vacuum chambers. These latter, of themselves, offer an additional elastic reaction which increases in amount with greater distension and diminishes as the chambers close together. The fixed, invariable, weight of the suspended mass can exactly counterpoise the air pressure on the cells for only one particular barometric pressure. A greater pressure will lift the weight and a lower pressure would permit it to fall by an indefinite amount, if the elastic restraint of the chambers themselves, or some equivalent effect,[2] does not operate to counterbalance the excess or deficit in pressure and thus establish a system which is in stable equilibrium.

We find, therefore, that in this weighted aneroid the real variations in air pressure are measured and registered entirely by the elastic reactions and deformations going on in the material of the vacuum chambers themselves. It is quite certain that the elastic properties of the chambers can not be so nearly perfect as those of finely tempered steel springs, and the writer is compelled to conclude that the barometric records by means of the weighted aneroids will still be found subject to appreciable, if not serious, errors of the kind so characteristic of all aneroids yet employed.

SNOW ROLLERS.

By Mr. WILSON A. BENTLEY. Dated Jericho, Vt., June 26 and July 5, 1906.

During the night of January 18, 1906, there occurred at and in the vicinity of Jericho, Vt., the very interesting and somewhat rare phenomenon of the formation by wind action of vast numbers of snowballs, or snow "rolls" or "rollers". A brief account of them, and of the weather conditions that prevailed before and while they were being formed, may possibly be of interest to the readers of the WEATHER REVIEW.

About five inches of very light, fluffy snow fell during the twenty-four hours immediately preceding the phenomenon. During this time the temperature ranged from 14° to 22° F. But during the night of the 18th, when the snow rolls were formed, the temperature slowly rose from 24° to 34° F., and the lower wind shifted from westerly to southerly points and blew at times in a very strong but intermittent and peculiar gust-like manner. The snow rolls were formed during the latter part of the night, after the rise to 34° was accomplished. This rise in temperature operated to cause a slight superficial melting of the upper layers of the snow and to make it slightly damp, so that the individual snow crystals tended to cling to one another.

So far as the writer was able to observe, and to learn from others in adjoining towns, the phenomenon occurred only over a quite limited and narrow strip of foothill country perhaps one mile wide, lying alongside and parallel to, but at a little distance from, the western side of the Green Mountains. The winds that produced the phenomenon blew across the valleys and foothills rather than parallel to their greater length. The topography of the region in question is such as to cause the winds that reach the valleys, or at least some of them, to flow or pour downward into them in descending order from foothills of considerable height.

In many cases the gusts of wind evidently had a strong descending motion, such as just described, for they actually scooped up considerable masses of the light, damp, fluffy snow and formed it into ridges or hollow snow arches, and rolled many of these up into snow rolls of various sizes.

The forms and structures of the snow rolls were such as to indicate that, at least in many cases, the wind that scooped up the fluffy snow masses into ridges or open arches, got in behind such ridges and arches (which may be termed "cores") and blew them over upon themselves or upon the snow directly in front and to the leeward of them, thereby imparting both rotary and forward motions to the snow core ridges or arches, blowing and rolling them along in this manner for some distance. Fresh layers of damp surface snow collected upon them as they rolled along upon the surface of the snow, and operated rapidly to increase their size and specific gravity. Eventually the rolls became so large and heavy that the winds were unable to roll them farther and they came to rest. Variations in exposure to winds and surface topography operated to cause some rolls to be blown along much farther than were others, hence some became of much greater size and weight than others. The individual snow rolls varied in size one with another, from tiny rolls but a few inches in diameter to huge ones 18 by 24 inches in size. In most cases the diameters of the rolls were much less than were their lengths.

Perhaps the most interesting rolls thus scooped up and modeled by wind action were those whose "cores" were of an open, hollow character. Such came into existence in the form of hollow snow arches, as previously described, and were so substantial, or were rolled along so gently by the winds, that their hollow cores were preserved intact, i. e., were not filled in as a result of collapse or of their rotary experiences. Figs. 1 and 2 show snow rolls of this character.

Unfortunately, the day following the formation of the snow rolls was a dark, cloudy day, unfavorable for photographic work, hence our original photographs of the snow rolls failed to show them with sufficient plainness, and it became necessary to increase their sharpness by recopying so as to produce extreme contrast effects. This explains why the trees, etc., show up so very darkly in these photographic prints.

The wind came from the right-hand side of these figs. 1 and 2. They show the paths of some of the rollers, and their beginnings on the right-hand side. The accumulation of snow occurring on the right-hand, or windward, side of each roller was, I am certain, not blown there from a distance by the wind,

[2] An automatic variation of the area upon which the air pressure is operative would be perhaps an ideal way to attain the desired end provided no frictions or elastic reactions were involved, but nothing of this character is comprised in the present instrument.